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EFFECTS OF RADIATION ON CANINE LOCOMOTION

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FOREWORD

The research reported in this paper was accomplished in the Radiobiology Division, under task No. 775705, from November 1968 to November 1969. The report was submitted for publication on 13 March 1970.

The irradiation of the dogs was performed at the TRIGA Fast Burst Reactor, Northrop Corporate Laboratories, Hawthorne, Calif., and at the White Sands Missile Range, N. Mex. Dosimetry measurements were made by EG&G, Inc., Santa Barbara, Calif., and by the Radiation Physics Branch at the School.

For their technical assistance, the author is indebted to Robert E. Cole and Alton Rahe of the Biometrics Division, as well as to Master Sergeant Hughes P. Rue of the Radiobiology Division.

The animals involved in this study were maintained in accordance with the "Guide for Laboratory Animal Facilities and Care" as published by the National Academy of Sciences–National Research Council.

This report has been reviewed and is approved.

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ABSTRACT

Sixteen dogs were used to determine the effect of ionising radiation on canine locomotion. The animals were run on a treadmill, at speeds of 3 to 5 m.p.h. for periods of 60 to 75 min., with intermittent rest periods. Microswitches were attached to each dog's feet to determine the downtime for each foot. The radiation exposures ranged from 380 to 5005 rads of neutron-gamma ratios of 1:20 for ten dogs and 9:1 for the other six animals. The most common symptom after radiation exposure was vomiting. However, the emesis did not appear to be dose dependent. Although changes in the support formula could be demonstrated after irradiation, no statistical significance could be applied because of the limited number of subjects involved and because of the great variation in exposure levels and in neutron-gamma ratios.

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I. INTRODUCTION

One of the major problems in studying performance decrement after high doses of radiation is that of gathering sufficient data on which to base statistically significant conclusions. This problem stems from the long training time required to condition animals to perform a difficult task with a high degree of efficiency.

Although primates may be the best models for man in studies on the effects of radiation on behavioral patterns, another suitable animal was sought as a model from which more data could be accumulated in a shorter period of time. This animal was needed in proposed research on a function in which changes in muscle tone, equilibrium, or coordination (or a combination) could not only be detected after irradiation but also recorded to allow accurate interpretation of minute changes.

The suggested animal was the dog, and the selected project was the examination of canine locomotion—or, more precisely, the support formula. The movements involved in locomotion display an extremely widespread synergy, incorporating the whole musculature and the entire moving skeleton, and bring into play a large number of areas and conduction pathways of the central nervous system (1). However, many of the reflex movements in maintaining equilibrium are initiated by proprioceptors in joints, muscles, or tendons; and these responses do not depend upon either the cerebral cortex or the cerebellum (2). As has been shown by slow motion photography, a great deal of variation exists between animals for any given gait; but, for the same animal, little change in locomotion occurs from day to day (3).

All of the previous investigators who used dogs on treadmills were seeking information relating to blood changes, respiration, or the effects of x-irradiation on physical exercise (4). No work has been done where locomotion patterns or support formulas were used to study performance decrement after supralethal doses of radiation.

II. MATERIALS AND METHODS

Mongrel dogs (1 to 2 years old, and weighing 10 to 20 kg.) were trained to run on a treadmill. The dogs were started at very slow speeds and for short periods of time until they became accustomed to the procedure. They were restrained on the treadmill, in a Plexiglas cage, by a harness snap attached to the cage and to a choke-chain. The training period lasted approximately two weeks.

The initial problem, of establishing both the exact instant at which each one of a dog's feet touched the surface of the treadmill belt and the time period during which each foot was in contact with the belt, was solved by use of a microswitch enclosed in 3120 RTV encapsulant and prevulcanized Silastic 372 (both are produced by Dow Corning Corp., Midland, Mich.). These switches were taped to the bottom of each foot. The signal device had to be: (a) moisture proof (to resist vomitus and feces); (b) dependable for several hours of use; and (c) capable of a fast response time.

The foot signals were relayed to a monitor panel and an oscilloscope so that the researcher could determine if all switches were functioning properly. The signals were also relayed to a tape recorder for future analysis.

Ten dogs were irradiated at the Northrop Corporate Reactor in July 1969. The neutron-gamma ratio was about 1:20, and the respective dogs received the following midhead doses:

Dog No.	*Midhead dose (rads)*
1	5005
2	3375
3	3260
4	3095
5	3215
6	3985
7	3105
8	4100
9	4270
10	3315

The dogs were baselined at 3 m.p.h. for 2 min., 5 m.p.h. for 2 min., and at 3 m.p.h. for 10 min. The animals were rested for 5 min. and the cycle was repeated. The radiation pulse occurred 1 min. after the dog began running the second cycle. Each animal was run for 3 periods (51 min.) postexposure, or until collapse.

Six dogs were irradiated at the White Sands Missile Range in November 1969. The neutron-gamma ratio was 9:1, and the respective dogs received the following midbody doses:

Dog No.	*Midbody dose (rads)*
1	1270
2	380
3	765
4	1200
5	1290
6	1050

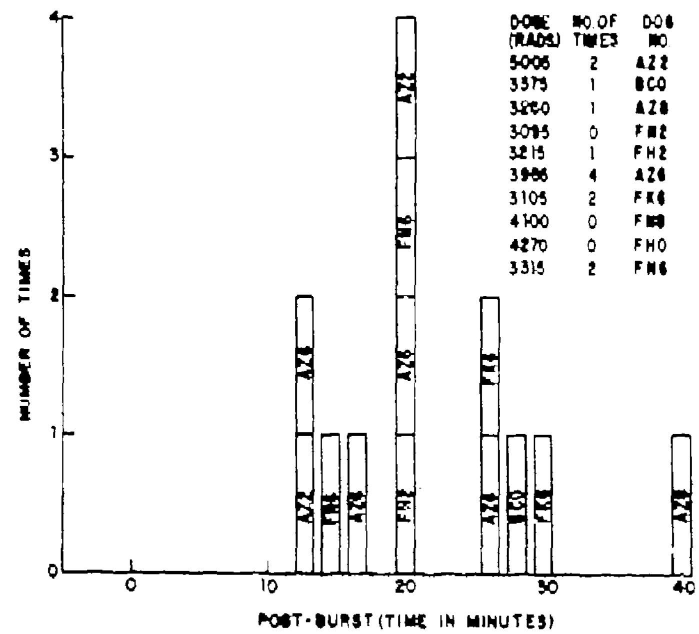

FIGURE 1

Emesis induced in dogs by irradiation at the Northrop Corporate Reactor.

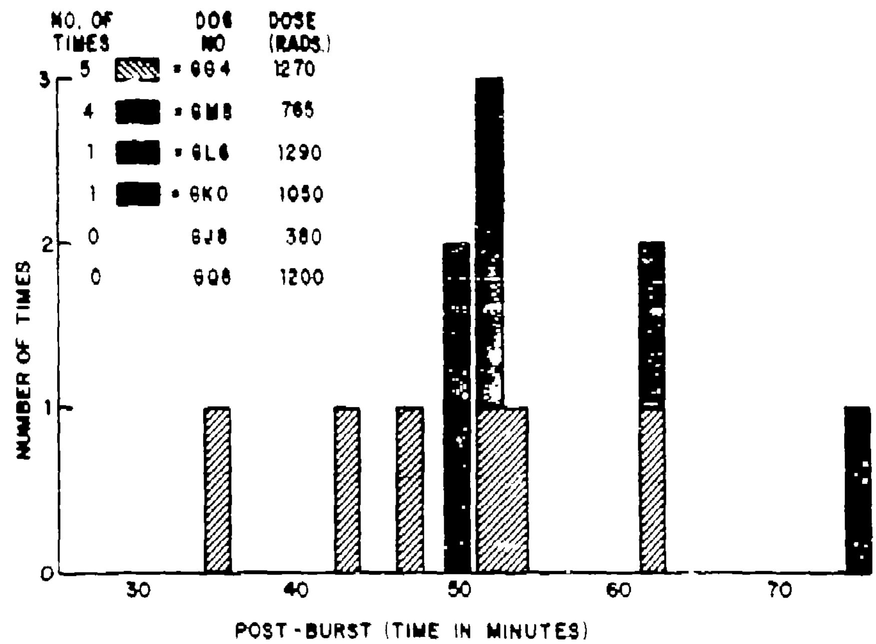

FIGURE 2

Resulting emesis in dogs exposed to radiation at the White Sands Missile Range Reactor.

These dogs were baselined at 3 m.p.h. for 15 min. They were rested for 5 min. and then were run for 1 min. before irradiation. Each animal performed for 4 cycles (74 min.) postexposure.

III. RESULTS

The most common symptom in the dogs after irradiation was emesis (figs. 1 and 2). Data on this symptom, observed in 11 of the 16 animals, are included in table I.

Within each group of dogs, no dose-to-emesis relationship was apparent. In the high-dose range, however, emesis occurred at about 23 min. postirradiation—and, in the low-dose range, at 52 min. postirradiation.

Any change in performance of dogs in the high-dose group was difficult to perceive until just prior to an animal's collapse. In the animals in the low-dose group, no change was visible; but the variation that occurred in the support formula of one dog (1290 rads) is illustrated in figure 3. This change is typical of all animals in the low-dose groups, except for the dog which received 796 rads.

Because of the unreliable reproducibility of the treadmill-belt speeds at the Northrop Reactor, pre- and postirradiation charts could not be compared with any degree of confidence.

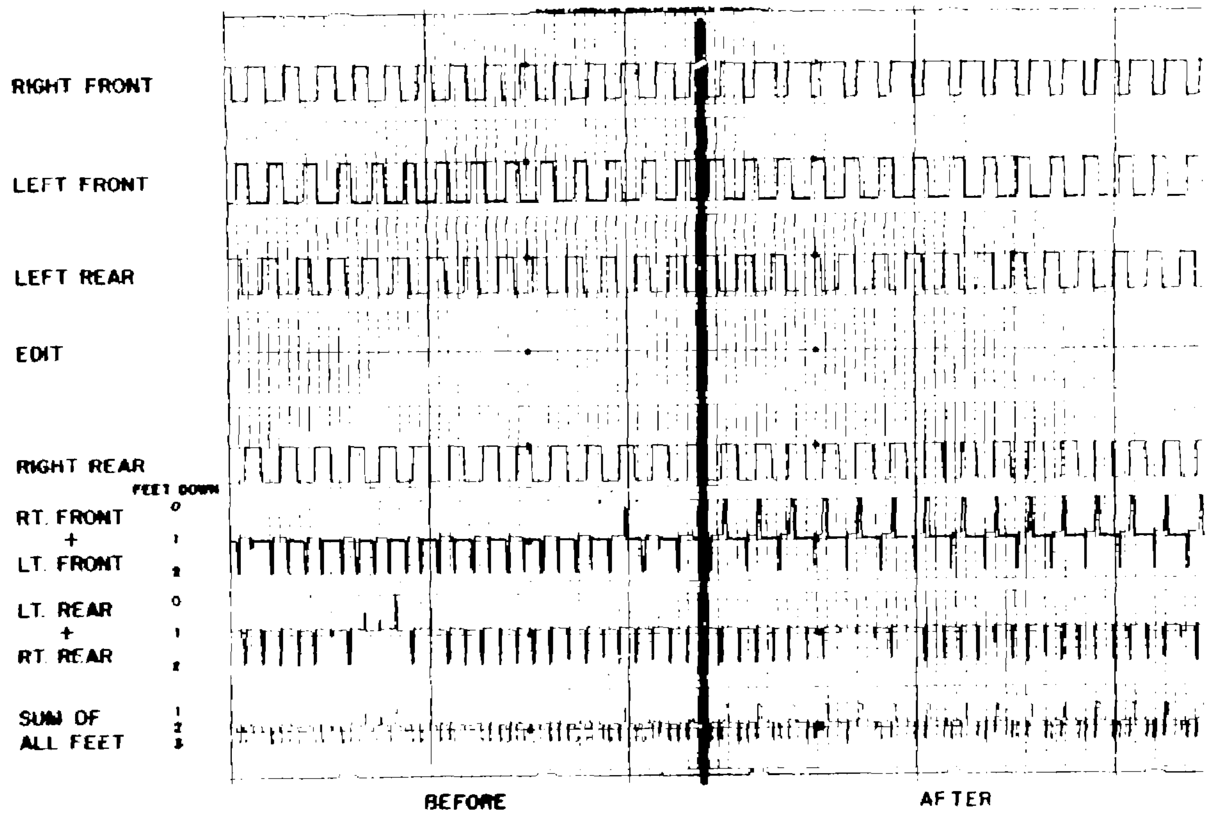

FIGURE 3

Changes in canine locomotion pattern after exposure to 1890 rads (of 8:1 neutron-gamma radiation).

TABLE I

Summary of data on irradiation of dogs

Dog No.	Dose (rads)	Emesis (No. of times)	Postirradiation time (min.)
1a	5005	2	14 - 20
2a	3375	1	28
3a	3260	1	40
4a	3095	0	Down at 11
5a	4215	1	20
6a	3985	4	13 - 26
7a	3105	2	26 - 30
8a	4100	0	Down at 26
9a	4270	0	Down at 8 and 12
10a	3315	2	14 - 20
1b	1270	6	35 - 62
2b	380	0	-
3b	765	4	50 - 74
4b	1200	0	-
5b	1290	1	50
6b	1050	1	52

a — at Northrop Corporate Laboratories
b — at White Sands Missile Range

IV. CONCLUSIONS

According to the results of this research, minor changes in the canine support formula occurred after the dogs received supralethal doses of radiation. The animals which collapsed after high-radiation exposure showed little change in locomotion involving equilibrium. No staggering or stumbling was observed in the animals until just prior to their collapse.

Only one animal that went down was able to get up and perform after a short rest period. This dog worked for about 2 min. before collapsing again.

In these two experiments, no statistically significant data were collected concerning the effects of ionizing radiation on canine locomotion; but the technics and methodology for measuring the minute changes in locomotion patterns were successful and may be applied to other experimental designs. Another important aspect of these experiments was the production of emesis.

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